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## **KDPOF-PHY**

Robust and low-cost MOST with 1000 Mbps for automotive

MOST Forum  
- April 2011



1. The company
2. The challenge
3. KDPOF PHY Proposal
4. Results



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# Company background

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KDPOF is a young company born in 2009

- Mission
  - Knowledge Development for POF (KDPOF) has the mission of developing **state of the art silicon** for Polymer Optical Fiber (POF) market, providing **low cost, low power** and outperforming **high speed** communications over POF
- Team
  - Team background on Telecom silicon development and automotive industry R&D
  - **Deep knowledge on telecom algorithms** and their implementation, as well as in **silicon commercialization**
- Motivation
  - We conceive POF as the perfect area for implementing state of the art digital telecom algorithms, going further than NRZ as the basic used modulation
  - POF market is growing and demanding **more and more bit-rates**, and at **longer distances**



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# Future Needs

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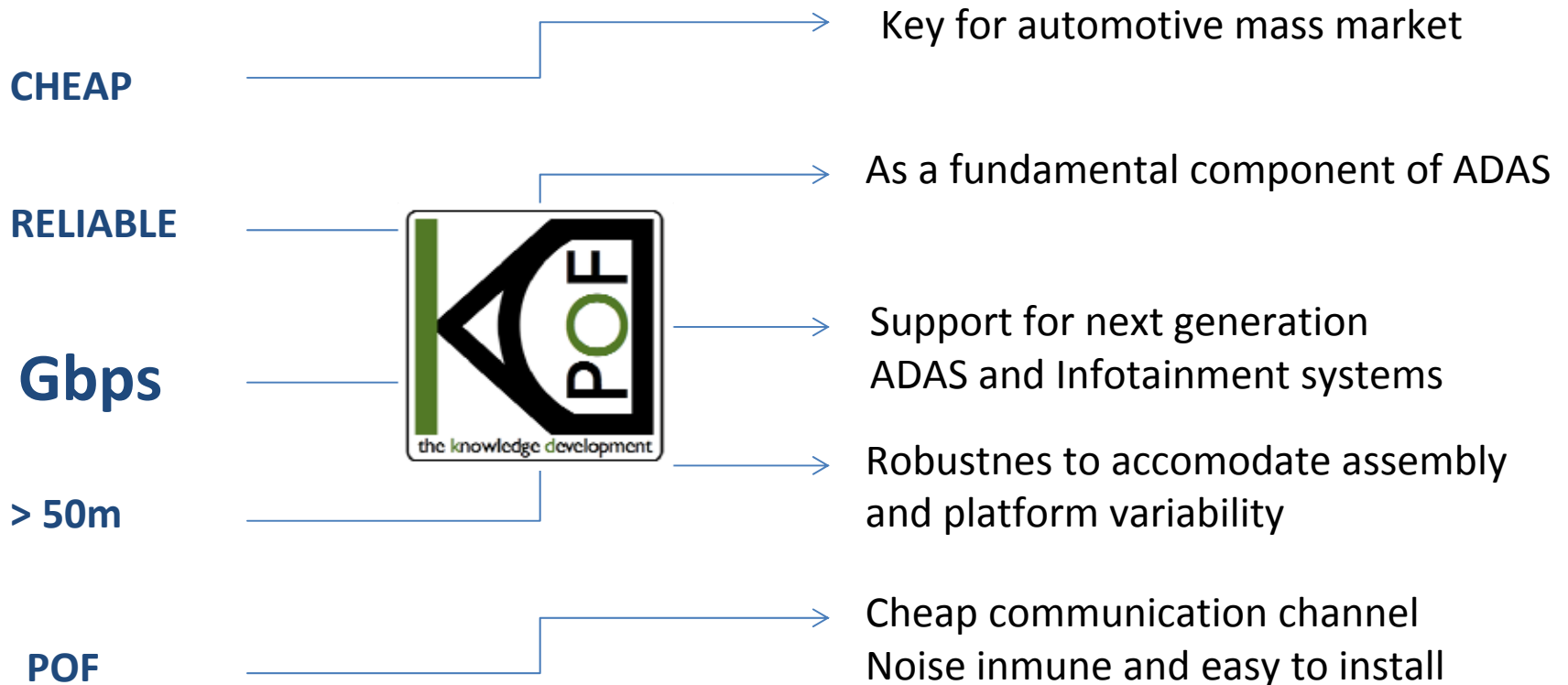


- **Future Automotive Infotainment networks will request:**
  - Higher bandwidths to support
    - Audio streams
    - Video streams
    - IP packets
    - ....
- **Future Automotive Safety networks:**
  - Reliable operation. Controlled latency. Sufficient link power margin.
- **Both of them will require:**
  - EMC proven
  - Lightweight
  - Reliability in front of installation and live.
  - Flexibility to support scalability and upgradeability
  - Cost control.

# KDPOF Value Proposition



***KDPOF is the only solution that provides cheap and reliable Gbps communications over >50m of POF links with current fotonic devices***

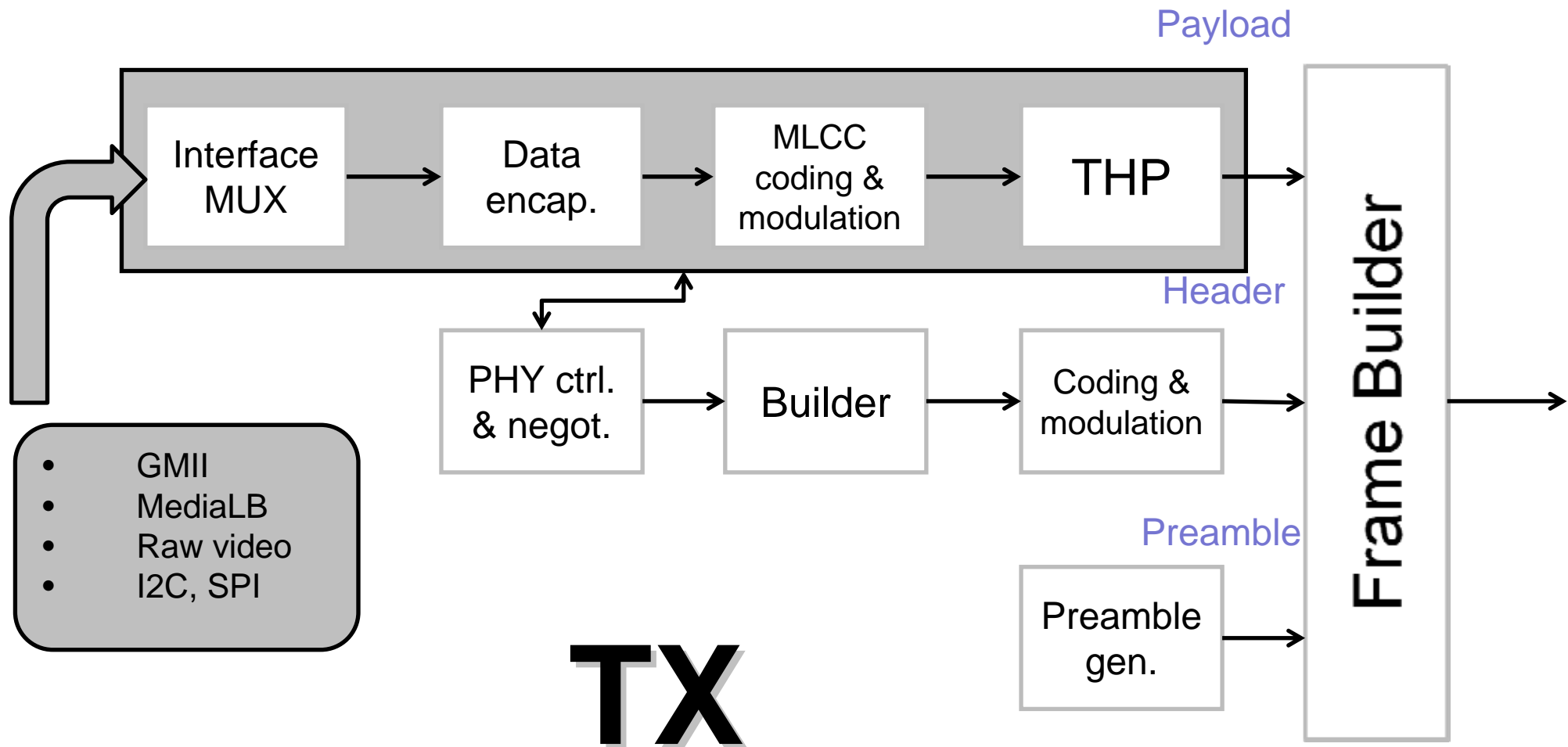




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- The physical layer is conceived in 3 modules implementing advanced techniques widely used in cable (10G base-T) and wireless communication (Wif-Fi) systems:
  - Modulation: Multilevel PAM
  - Equalization: THP
  - Coding: MLCC
- And a
  - Frame structure: Allows channel adaptation and half/full duplexing.
  - Low power mode operation.

# KDPOF technology



# KDPOF frame building

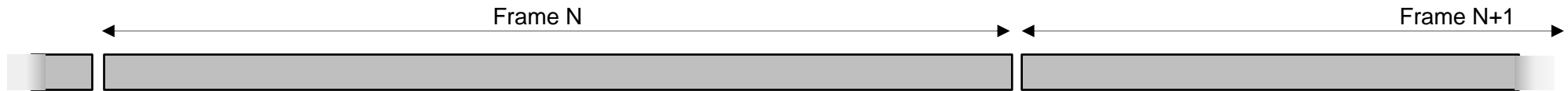
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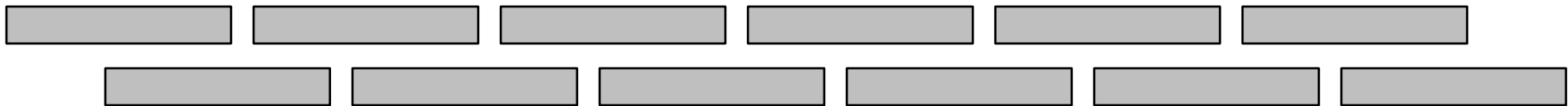
- The encapsulation of higher layers in the physical layer requires a flexible and efficient frame building.
- Frame is built with:
  - Preambles of the correct size for synchronization and equalization
  - Headers for announcing the basic physical layer parameters
  - Payload to encapsulate higher layers data with FCS
- The frame is flexible and robust, allowing fast adaptation on channel conditions, as well as negotiation of the possible modes.

# Frame structure

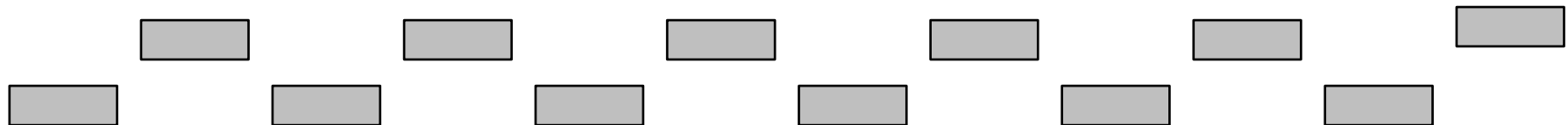
- Frame has Preamble, Header and payload.



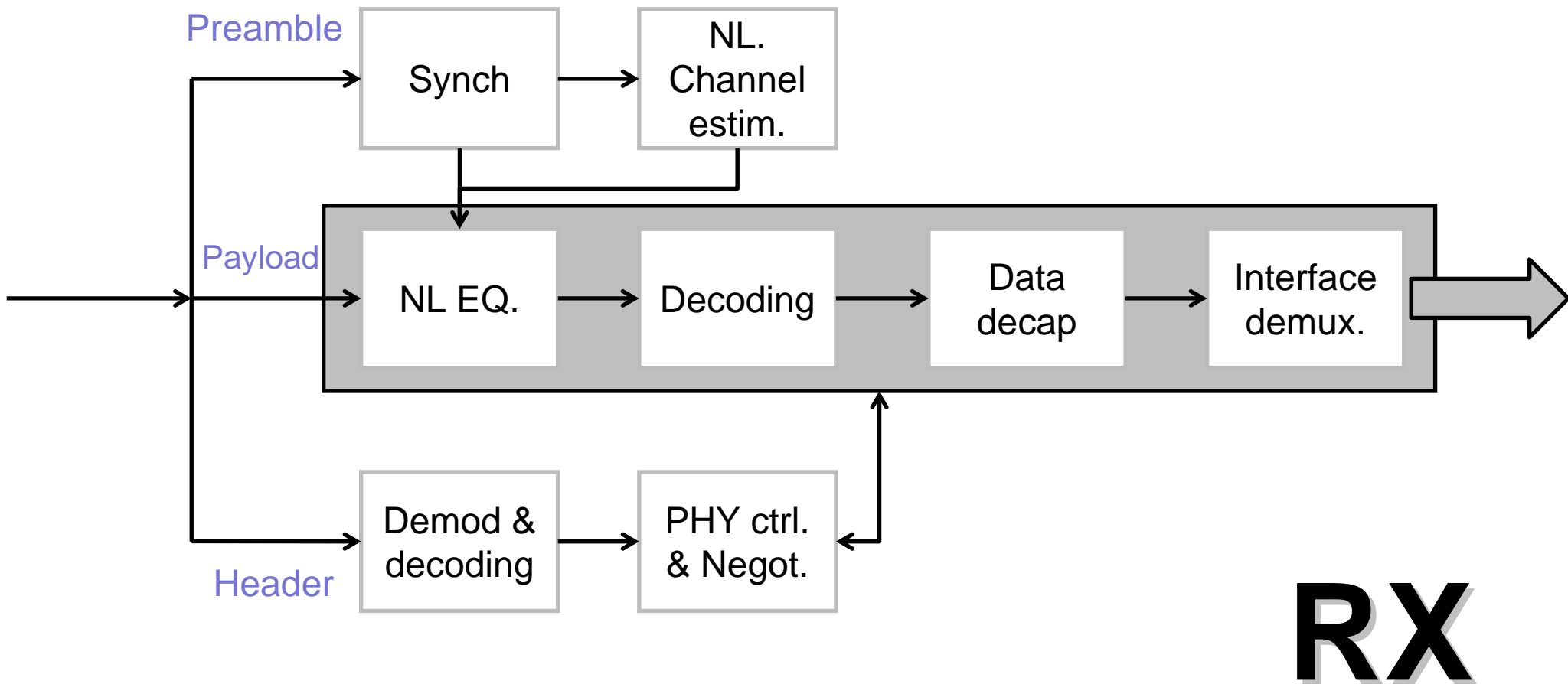
- In full duplex, frames in both directions are asynchronous between them. (Dual fiber)



- In half duplex, frames are generated synchronously X% each direction. (Single fiber)



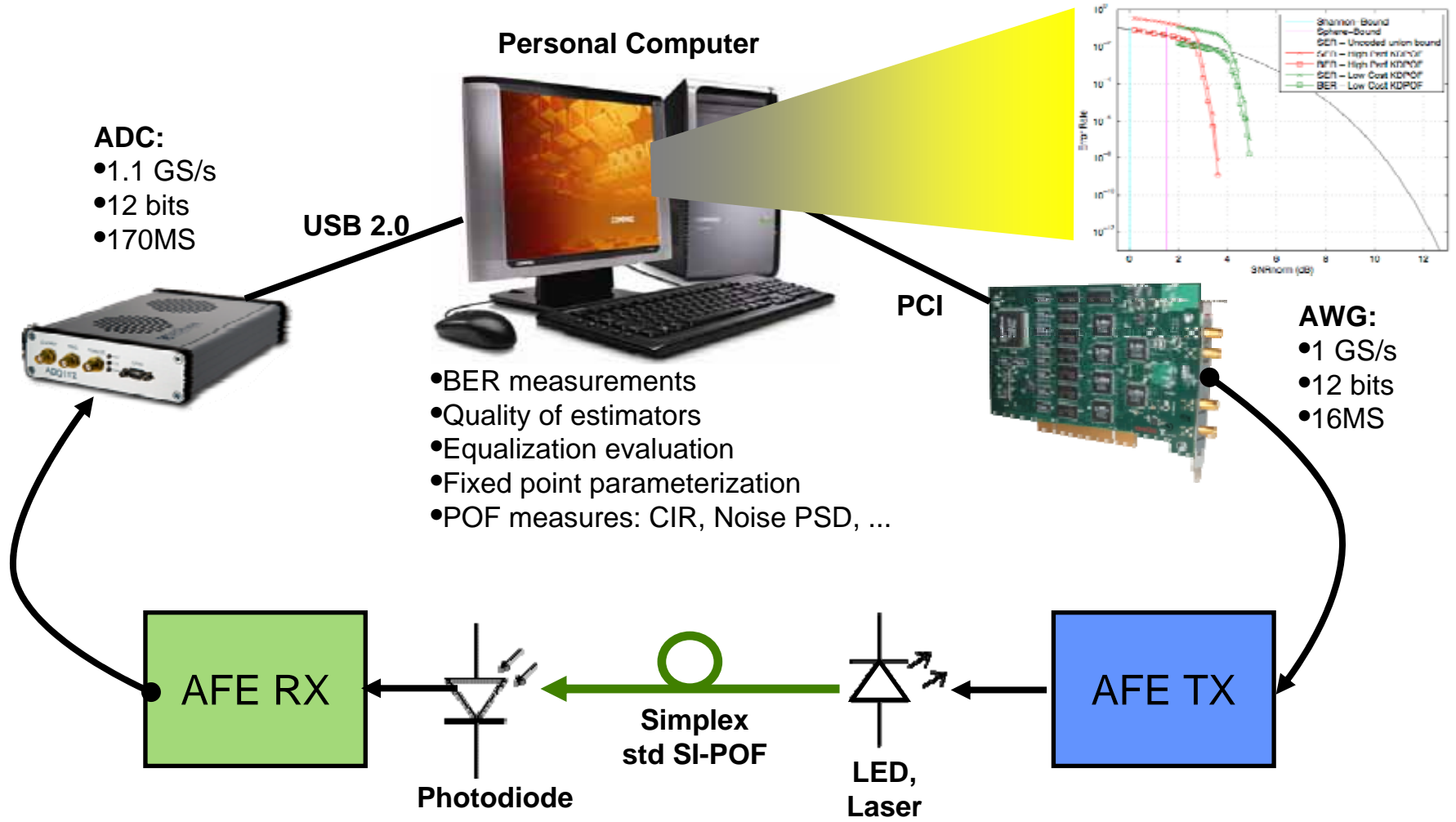
# KDPOF technology



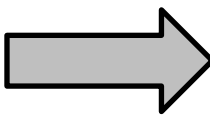
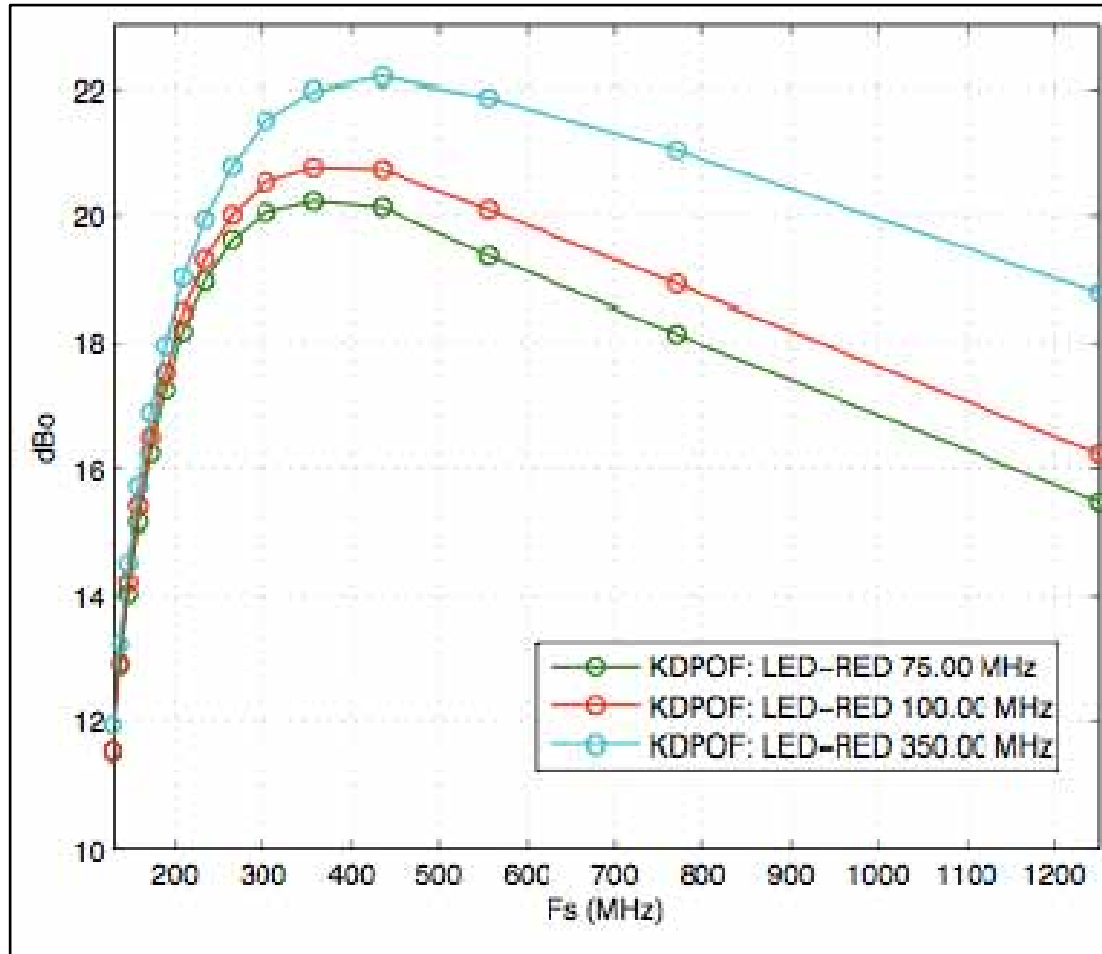


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# Demonstrator



# KDPOF MOST 1000 Mbps - link budget results



Optimum sampling point 312,5 MHz  
16-PAM  
Eff: 3.3 bits/symbol

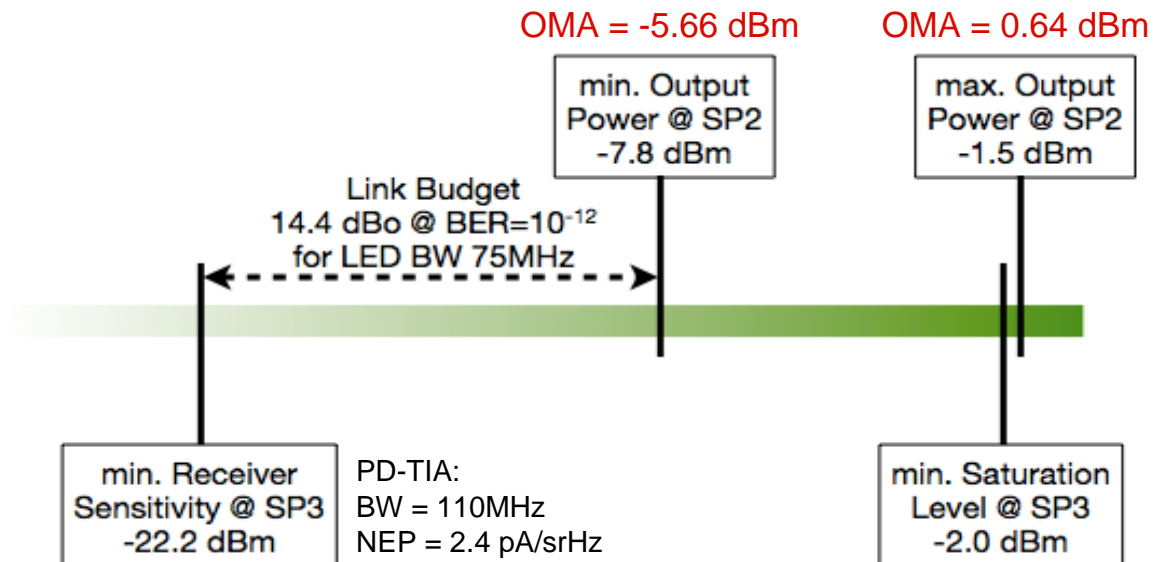
- N/A 0.3, Poma= 0 dBm. Bandwidth 75-100 MHz
- 20 m SI-POF (A4a.2). Attenuation within link budget.
- State of the art receiver. Responsivity 0.5 A/W @ 650 nm.

OMA = 0dB referred link power budget for KDPOF MOST1000

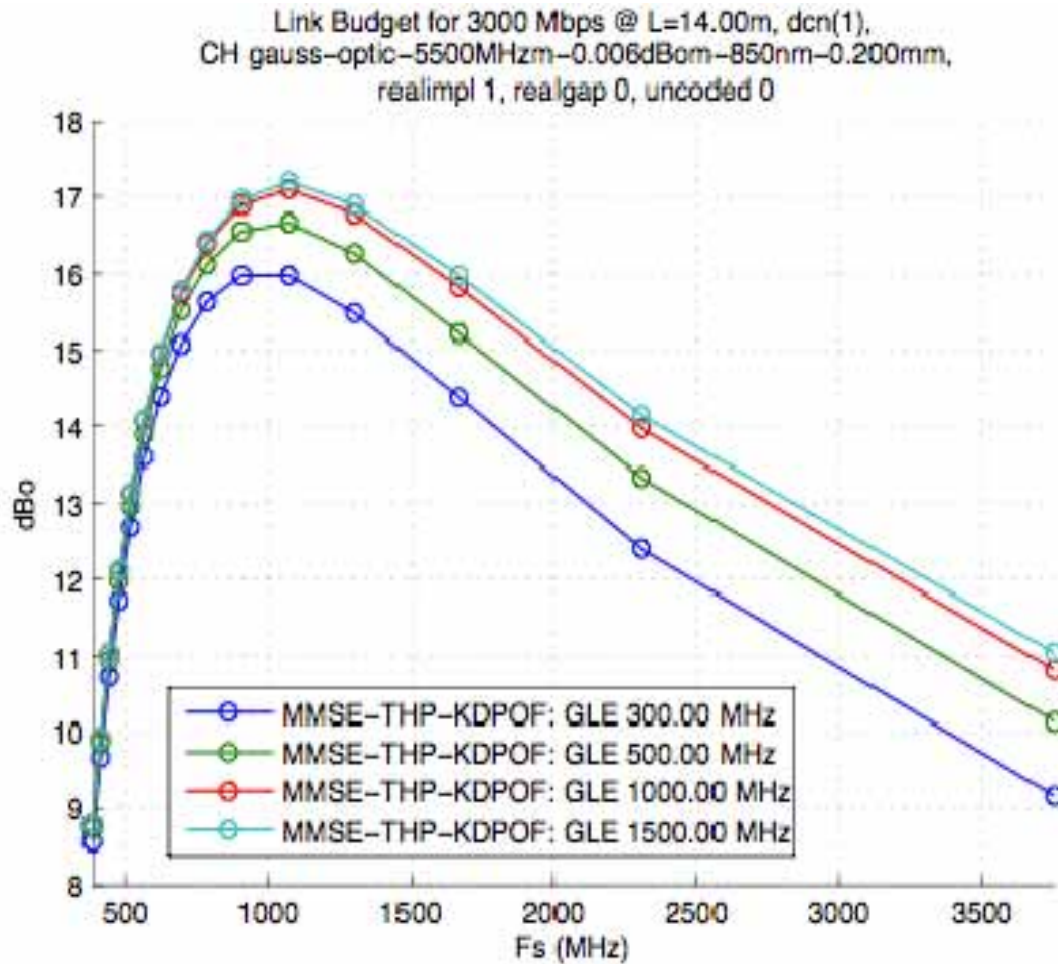
# KDPOF MOST 1000 Mbps - link budget results



LED bandwidth (MHz)	Link budget for OMA 0dBm at SP2	Link budget SP2 - SP3 for min power at SP2 -7,8 dBm (OMA - 5.66 dBm)	SP3 sensitivity (dBm)
75	20,1	<b>14,4</b>	-22,2
100	20,6	<b>14,9</b>	-22,7
350	21,6	<b>15,9</b>	-23,7



# KDPOF MOST 3000 Mbps – Can we go further?



Proposed by



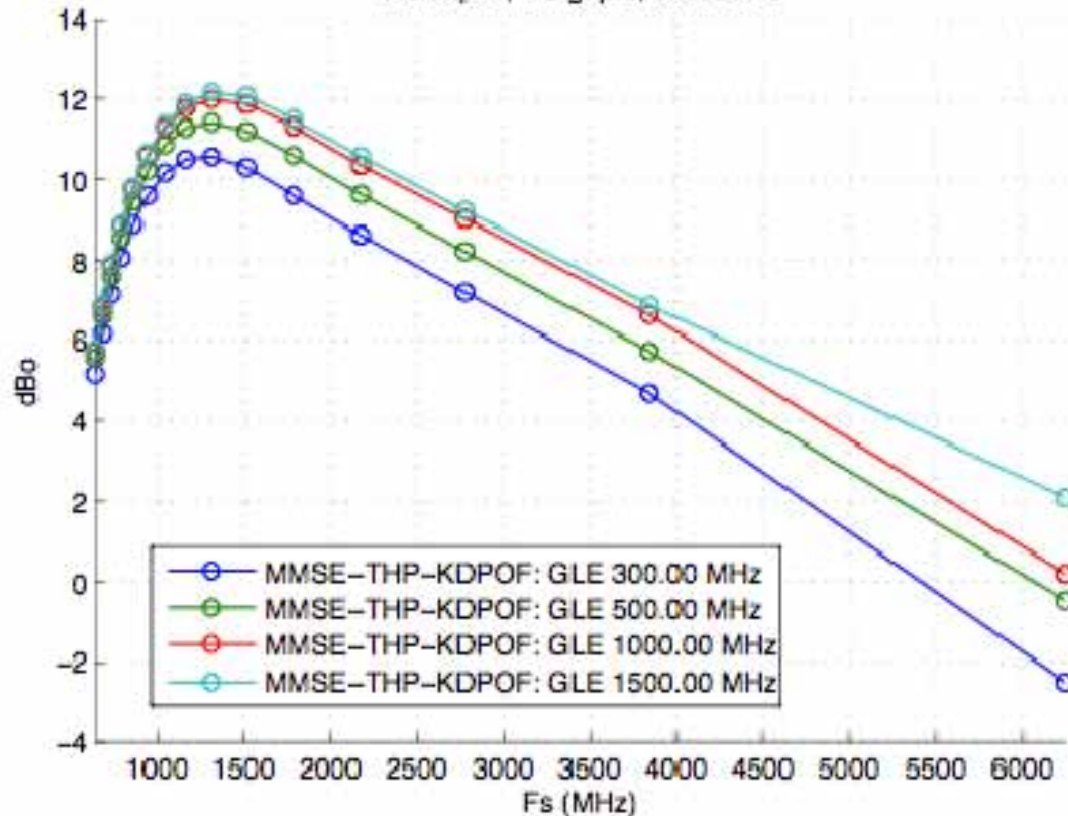
- VCSEL - 850 nm
- PCS 200um core - 14 meters
- Photodiode (350 Mhz) and TIA (Si OPA based)
- ADC at ~1GHz!!

**MOST 3000 Mbps is feasible with link budget 17 dB0**

# KDPOF MOST 5000 Mbps – Even further?



Link Budget for 5000 Mbps @ L=14.00m, dcn(1),  
CH gauss-optic-5500MHzm-0.006dBom-850nm-0.200mm,  
realimpl 1, realgap 0, uncoded 0



Same HW as MOST 3000 Mbps

MOST 5000 Mbps with current model has not enough margin.

- Bandwidth limited by fiber
- Are assumptions too tight?

For 1GHz VCSEL, the optimum is at ~1350 MSps

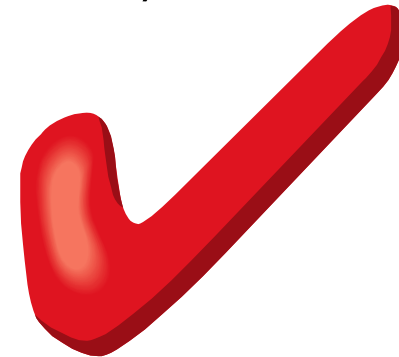
- 16-PAM, 3.8 b/symb

ADC at >1GHz: it is challenge

# SUMMARY

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- KDPOF's MOST 1000 Mbps PHY Link budget between SP2 and SP3 similar to currently available MOST150 products.
- KDPOF's MOST 1000 Mbps PHY proposal is a reliable, robust and future proven solution.
- KDPOF's MOST >1000 Mbps is feasible with PCS (MOST 3000 Mbps demonstrated and MOST 5000 Mbps TBD).
- Key dates:
  - June 2011. FPGA. Key users and integrators.
  - Jan-Feb 2012. Engineering samples.
  - May 2012. Production





Thank you for your attention

BACK UP SLIDES

# KDPOF modulation

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- **KDPOF uses a multiple levels PAM modulation technique.**
- The PAM level is defined by the bandwidth, the required bit rate and the coding.
- **The system is able to adapt the PAM level according to the available SNR.**
- The minimum PAM is 2, and the maximum is 64.
- The transmitter announces the supported PAM levels, and the actual PAM level used in the transmission.
- **The receiver request a certain PAM level and coding rate based on the SNR.**
- The PAM level is negotiated at the same time than the coding.
- **Modulation and coding are inter-related in MLCC**

**For 1 Gbps with maximum link power budget over SI-POF 16-PAM with 312.5 Mbaud is the best choice**

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# KDPOF equalization

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- The channel and the noise are equalized with an advance technique.
- **Distortions created by the fiber and optoelectronic devices are compensated.**
- **Both lineal and non linear components of the channel response are compensated.**
- **Equalization based on Tomlinson-Harashima Precoding**
- **High impact on link budget**

# KDPOF channel coding

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- Current state of the art coding like LDPC and Turbo-Code are very expensive in terms of silicon area and power consumption when managing a bit rate of 1 Gbps.
- KDPOF technology uses a low power Multi-Level Coset Coding and binary BCH component codes, which minimizes the silicon area and power while keeping very good error correction performance.
- Coding provides a gain of 3.5 dBo for  $BER < 10^{-12}$